Purified Water Supply System For High Demand Devices and Applications

Introduction

The present invention relates generally to water supply systems, and more particularly to a system adapted for supplying purified water to one or more water using devices, some of which having distinctive water consumption demands, including devices having distinctively and usually intermittently high demands versus devices having low demands for flow rates and/or volumes of purified water. This invention further presents particular advantages in medical and like high quality purified water supply systems such as in allowing for the supply of water to both high demand dialyzer reprocessing machines and lower demand dialysis machines without substantially increasing the total operational volume or flow rate of purified water flowing through the entire water supply system.

Background

There are presently a variety of industrial and medical devices and associated procedures that require the use of purified water. A prominent example is found in medical dialysis. In such dialysis procedures generally, including hemodialysis, hemofiltration and hemodiafiltration processes, blood to be dialyzed is taken from a patient and passed through a dialyzer where the blood is cleaned of its impurities and then returned to the patient. Contemporary dialyzers are ordinarily of a membrane type in which the blood may be passed along one side of the membrane, while in the most common types of dialysis, another liquid, often called dialysate, may be passed along the opposite side of the membrane. This process is conceptually the same in plate, hollow fiber and coil dialyzers. Ideally, impurities in the blood pass from the blood through the membrane and into the liquid dialysate. The liquid dialysate carrying these impurities then flows out of the dialyzer and is usually passed through a dialysis control monitor or machine to a drain. Some types of dialysis also include providing a replacement liquid to the patient, the replacement liquid being passable with the blood through the dialyzer, or otherwise often being infused directly into the blood returning to the patient.

The dialysate and replacement liquids are both generally made from purified water into which various additive solutions and/or powders are mixed to create respective liquid solutions that are usually substantially isotonic to blood. Often this mixing of additives with purified water may be effected at and/or by each discrete dialysis machine (also known as a monitor) during each dialysis session. This process is often referred to as on-line dialysate or replacement liquid preparation. A centralized, substantially continuous supply of purified water may then preferably be presented to one or more of such on-line dialysis machines in a particular setting such as a hospital or a dialysis clinic for the preparation of these respective liquids during operation.

In a centralized water supply system such as this, it is common to provide a centralized purification arrangement including a reverse osmosis (R/O) apparatus or unit and/or a de-ionization (DI) apparatus or unit among other purification devices, such as carbon and/or mechanical filters and/or chemical treatment devices such as water softeners. There may also be additional water treatment for the removal of bacteria and/or endotoxins or the addition of or subjection to electromagnetic waves, e.g., ultraviolet light for the inactivation or destruction of such pathogens. In any event, the R/O or DI unit commonly establishes the last purification step in the purification arrangement which, as is known in the art, then provides output purified water to medically acceptable and/or otherwise preferable or desirable quality or like standards.

As mentioned above, this purified water may then be delivered in a typical dialysis setting to one or a plurality of dialysis machines, preferably through short branch connections emanating from a main or central supply line. The central supply line may then provide for the flow any unused water to a drain or it may form a circuit by feeding back into one or more of the purification devices (such as the R/O unit) for re-purification and/or to other units (such as a central storage tank) and then/thereby provide for recirculation out to and through the central supply line circuit.

Other machines that use purified water have also been known to be commonly connected to such a centralized water supply line. An example particularly fitting within a hospital or dialysis clinic setting is the connection to the purified water circuit of one or more dialyzer re-use

machines (also known as dialyzer reprocessing machines). As is understood, dialyzer re-use machines use the purified water to clean dialyzers after respective dialysis sessions for re-use in later dialysis procedures.

One common concern arising from such an incorporation of dialyzer re-use machines is the relatively high water demand such re-use machines usually require to complete their cleaning procedures. Re-use machines normally require a high volume (though usually intermittent) flow rate of water, albeit usually for a short time period when compared with the lower (usually more constant) demand, longer term dialysis machine use. However, contemporary centralized purified water circuits often have relatively constant maximum output flow rates, depending ordinarily upon the maximum output of the respective R/O unit if, as is common, the R/O unit feeds directly into the main water supply circuit. The high demands of one or more re-use machines connected to a main supply line can then significantly negatively impact a centralized water supply system having an R/O unit which directly feeds water at a constant maximum output. The negative impact of the high demand is such that it may overburden the main water supply system by drawing too much water flow from the main supply line to the point that the flow of purified water provided simultaneously to any other water using machines such as one or more dialysis machines may be reduced, interrupted or the central line pressure may be decreased sufficiently so that one or more of the dialysis machines do not have sufficient water volume or pressure to continue producing dialysate and/or replacement fluid, as needed for the dialysis procedure, and may thus be forced into an alarm state and possible automatic shut-down. Such alarms and possible shut-downs may then provide a danger to the dialysis patient(s).

Note, R/O and/or DI feeding into intervening holding tanks is known in the art. However, such tanks have been disposed in the primary water circuit, and as such are often necessarily unacceptably too large (approximately 250 gallons) for many medical/dialysis settings and/or have too many stagnation areas (as in bladder surge tanks) thus providing unacceptable opportunities for undesirable biological and/or microbiological growth. Additionally, these prior holding tank systems must maintain high flow rates throughout their piping systems to maintain turbulent flow which minimizes bacterial growth. There are usually large pressure drops through such piping systems due to the high flow rates and long lengths of

the piping system as well as due to the number of taps for each water using unit to be attached to the piping system. Intermittent high demand devices such as dialyzer re-use equipment draw large amounts of water out of the piping system in a short period of time. This may cause the pressure levels to drop sharply throughout the piping system, thereby likely causing both the re-use equipment and any other attached water-using equipment, such as dialysis machines, to not have sufficient water volume and/or pressure to operate properly.

Other industrial water usage machines and water supply circuits may also suffer similar drawbacks. Such systems may include pharmaceutical preparation processes and/or electronic device (e.g., microchip) manufacturing processes. Thus, any system which may include the use of both low and high water demand devices on a water supply line may take advantage of the present invention.

Hence, a need exists for providing for a safe, non-overburdensome connection of high water demand devices, like dialyzer re-use machines, to a water supply line so that other lower demand machines, such as dialysis machines, may be provided with a sufficient, uninterrupted supply of water volume, pressure and/or flow rates to maintain normal operations. It is toward this and related aims that the present invention is directed.

BRIEF SUMMARY OF THE INVENTION

The present invention is directed to the provision of a water supply sub-system which is connectable to a centralized or main water supply system. The sub-system provides for the connection of one or more relatively high demand water using devices in a substantially isolated or lower demand disposition relative to the main water circuit. Generally, the present sub-system includes a sub-system storage tank which is connectable to the main water supply system, and a sub-system water line to which the high demand device or devices may be attached. This sub-system water line (also referred to in some recirculatable embodiments as a loop, see below) is connected to and leads from the sub-system storage tank, through a pump to one or more outlet connections for a potential variety of generally high volume flow rate demand, short duration

water use devices such as dialyzer re-use machines. This further sub-system water line may be dead ended (thus, no loop), or run to a drain or drain connection, or more preferably, it may feed back to the sub-system storage tank for recirculation therethrough (and, thus form a loop). A shunt line may additionally or alternatively be connected to the sub-system water line to provide pressure control for the output from the pump, and/or for more directly feeding from the pump back to the storage tank for the same or perhaps a similar general recirculation purpose. At least one of these recirculation lines preferably feeds into or near the top of the storage tank and feeds through a spray head arrangement therein (thus completing the loop) which disperses the incoming water in a substantially continual spray configuration to maintain a substantially constant movement, non-stagnating air to water interface within the tank. This assists in maintaining a preferably more sterile environment within the storage tank. The other feedback line may preferably feed into a lower part of the storage tank to counteract vortex action at the tank outlet. A microbiological filter and/or various other components may also be included in or along the sub-system water line to ensure and/or increase operational effectiveness and/or efficiency.

In use, purified water may be taken into the sub-system storage tank from the centralized supply system at a substantially controlled, relatively constant low rate so that a substantially no or low fluctuation demand is presented by the sub-system to the central or main supply system. The tank can then feed a short duration, higher volume flow rate to the rest of the sub-system, which, including one or more high water demand devices, can then draw the respective higher flow, higher volume demands from the outflow of the sub-system storage tank while the storage tank continues to draw the preferably constant, substantially lower maximum volume flow rate from the main supply system. This high demand draw may have the effect of drawing down the total volume contained within the sub-system storage tank, but does so generally for only a comparatively short duration and preferably not to an empty state. The maximum intermittent high demands of the high demand devices may thus be accounted for within the total operating storage tank volume. The high demand devices may then be operated at any time during which the storage tank contains a sufficient residual water volume without then impacting on or interrupting the main supply of water to the lower demand, longer duration dialysis or like machines connected directly to the main line.

As noted, systems of the present invention may be highly beneficial in purified water supply systems such as in medical applications like dialysis, or may also be useful in pharmaceutical preparation or electronics manufacturing or other water supply processes.

These and other aspects of the current invention will become clearer from the description of preferred embodiments considered in conjunction with the attached drawings which are described briefly below.

Brief Description of the Drawings

Accordingly, in the drawings,

Fig. 1 is a schematic view of a centralized purified water supply system in which the present invention may be incorporated;

Fig. 1A is a schematic view of an alternative centralized purified water supply system in which the present invention may be incorporated;

Fig. 2 is a schematic view of a water supply sub-system according to the present invention as connected to the centralized purified water supply system of Fig. 1;

Fig. 3 is an enlarged schematic view of a preferred alternative sub-system according to the present invention, shown detached from a central water supply system; and

Fig. 4 is a schematic view of a sub-system like that in Fig. 3 showing a further alternative line connection.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

A centralized or main water supply system **10** is shown in Figs. 1 and 1A including a water treatment or purifying unit **12** which feeds purified water either directly into an outlet purified water supply line **14** (Fig. 1) or indirectly to line **14** via an intervening storage tank **13** (Fig. 1A). Unit **12** is preferably here a reverse osmosis (R/O) or de-ionization (DI) unit **12**, and either of these or other types of treatment units may be considered here even if R/O is used in the description here. Water line **14** is the distribution line which may also be referred to as the main line **14** herein to distinguish it from various other water lines to be described throughout this specification. An inlet feed line **15** which feeds into treatment unit **12** will be understood as feeding water from any of various sources or combinations of sources (none shown) such as from a tap and/or from one or more pre-treatment or filtration devices (carbon and/or mechanical filter(s) and/or chemical or water softening or like water treatment device(s), for example, none shown). Moreover, feed line **15** may also alternatively receive feedback water from the purified water line **14** via a connecting line **17** (shown in dashed lines in Figs. 1 and 1A) to create a main supply circuit or loop **16**. An alternative feedback line **17a** (Fig. 1A) provides for feedback of water to the storage tank **13**, if used.

The water system main line **14** is shown having a plurality of connection branches generally designated in Fig. 1 with the reference numeral **18**. One or more water using machines **20** may then be connected through respective branches **18** to the central or main water line **14**. In this description particularly of Fig. 1, machines **20** may be considered relatively generically such that they may be understood to represent, for example, one or more dialysis machines, and/or for another example, one or more dialyzer re-use machines, *inter alia*. As was described hereinabove, it has been known in the art to connect one or more dialysis machines and/or one or more dialyzer re-use machines to a single main water supply line **14**. Further devices, machines or outlet taps have been known to be similarly connected to a main line **14** in a dialysis setting as well, including, for example, taps for centralized bicarbonate concentrate preparation, dialyzer pre-rinse or dialyzer cleansing devices (e.g., for cleaning a dialyzer prior to use of the dialyzer in a dialysis process, also referred to as pre-cleaning devices, herein), and/or pre-rinse sensor or sink cleansing devices. Any such devices are intended also to be represented interchangeably by the

generic reference numeral **20** in Fig. 1. Water used thereby may then be flowed to a drain via a respective drain line **21**. This water may alternatively be returned to the inlet of the treatment unit **12**, see line **17** in Fig. 1, or to a central storage tank **13**, see Fig. 1A.

Nevertheless, because of the pressure fluctuations in main line **14** caused by high demand devices, in the present invention, the direct connection of generic water use machines **20** as shown in Fig. 1 to the main line **14** is preferably restricted, as shown more particularly in Fig. 2, to the connection of low water or substantially constant water demand machines **20A** (Fig. 2). Thus, the generic water machines **20** of Fig. 1 which are directly connected to main line **14**, are hereafter referred to in the present invention as low demand machines **20A** (Fig. 2). Low demand machines **20A** include, for example, dialysis machines. Higher demand machines **20B** (see Fig. 2), such as dialyzer re-use machines will, according to the present invention, be connected to and/or within a water supply sub-system which is identified schematically in Fig. 1 by the box designated **25**, and is shown in more detail in Fig. 2 within a dashed box outline similarly identified by the reference numeral **25** therein.

More particularly in Fig. 2, a sub-system inlet line **26** is shown schematically connecting the water supply sub-system **25** to the main line **14** through its connection at one end of line **26** to a main system outlet branch **18** of the main line **14**, and at the other end to a sub-system storage tank **28**. Emanating from tank **28** is a storage tank outlet line **30** which flows to a pump **32**. Pump **32** is preferably of a centrifugal type which may thus be pressure controlled at the outlet thereof as will be described below. At the outlet of pump **32** is an outlet line **31** which is connected to or is coincident with a sub-system supply line **33** which provides water to one or more branch connections **34**, to which may be connected one or more respective water using machines, such as the representative high-demand machine **20B** shown in Fig. 2. Note, tank outlet line **30**, pump outlet line **31** and supply line **33** may be separate elements, or they may all be contiguous or coincident with each other (depending upon the pump type used), or in either event, they may be simply considered to comprise a single outlet supply line for simplicity of description.

Also shown in Fig. 2 are three alternative additional flow paths (shown in dashed lines), at least two of which providing preferred alternatives to the dead-ended supply line **33** indicated in Fig. 2 by the dead-end **35** (dead-ended refers to the non-recirculating flow stopping effect the dead-end **35** provides at the end of supply line **33**). The first alternative is a drain line **36** which provides a drainage flow path for unused water to flow to a drain (not shown). The second alternative flow path which is presently preferred over or at least in addition to a drain line **36**, is a feed-back loop **38** which provides for flowing any unused water back to the storage tank **28** for recirculation as described in more detail relative to Fig. 3 below. The third alternative flow path is provided by a feed back shunt line **40** which is disposed upstream of the branch connections **34** to provide for the alternative of providing pressure regulation and recirculating unused water to the storage tank **28** simultaneously with (or perhaps without) flowing the unused water through the entire loop **38**. Preferably, all three alternatives to the dead-end **35** will be provided in sub-system **25**. However, any one or more of these alternative flow paths (or none of them, as depicted in Fig. 2) may be disposed in a sub-system **25** according to the present invention and could be simultaneously so connected and may be connected by shutoff or three-way valves or the like (not specifically shown). Any one or more of these flow paths may thus be chosen for directing water flow therethrough at any given time as may be desired. Further examples of such flow choices and the preferred purposes therefor will be described below.

A further detailed embodiment of a preferred sub-system **25** according to the present invention is shown in Fig. 3. Many of the alternative elements included herein are preferred within the scope of the present invention, but may be added to, substituted for or eliminated as may be appreciated by those skilled in the art. Inlet line **26** preferably also includes a connecting device **42** and one or more valves, preferably a check valve **44** and a flow control valve **46**. The connecting device **42** is preferably a male connector which may or may not include a shutoff which would mate with a female connector **43** which preferably includes a shutoff (not shown) disposed in or attached to the branch **18** or directly emanating from the main line **14** (thus constituting the branch **18**, shown schematically in Fig. 1). The check valve **44** maintains flow in one direction from main line **14** to the tank **28** and is preferably disposed adjacent or near the connecting device **42**. The flow control valve **46** may be more preferably disposed adjacent the inlet **48** to the storage tank **28**. The flow control valve **46** provides for flow rate control into

tank **28**, and in the preferred embodiment is not variable or operator manipulable. Rather, valve **46** is preferably a manufacturing chosen size based on the maximum burden to be presented by the one or more high demand machines (see **20B**) considered in combination with the lowest acceptable main water line supply minimum flow rate with which sub-system **25** may be used. This may thus take into account the quantity and type of lower demand machines (dialysis and the like, e.g.) which may be designed to be connected to the main line **14**. Different sized valves **46** could thus be used depending upon the quantities and/or types of lower demand devices **20A** might be used, as well as what the operating output of the particular purification unit **12** being used. Valve **46** may also, in a less preferred alternative embodiment, be used to provide manual on/off control of flow into tank **28**.

Inside the storage tank **28** (shown in cross-section in Fig. 3), an extension **49** of the inlet line **26** preferably runs from and/or through a float valve **50** to provide inlet flow into tank **28**. Water flowing into tank **28** through inlet line **26** would preferably flow through valve **50** and the extension **49** to fill the tank **28**. As the tank fills with inlet water to a pre-determined level, the water will move the float arm assemblage **51** upwardly and thereby cause closure of float valve **50** and halt further water inflow into tank **28** through line **26**.

Storage tank **28** also preferably has a vent **54**, an access port **55** and a disinfectant inlet port **56**. Vent **54** is preferably a 0.2 micron porous membrane filter vent to allow air flow therethrough, but not ingress of biological contaminants such as bacteria. Substantially atmospheric operating pressures may thus be achieved within tank **28**, though without risk of contamination. Access port **55** allows operator access for manufacturing, maintenance, parts replacement or cleaning as desired, and port **56** provides for flowing disinfectant solution therethrough into tank **28** for disinfection procedures carried out on a preferably regular basis (see description below).

One or more recirculation inlets **58**, **68** are preferably also provided in storage tank **28** for connection, as described below, of one or more recirculation loops. The first such feedback loop **38** is connected to tank **28** via a first inlet line **41** through inlet **58**. An inlet extension line **59** extends through inlet **58** to provide for communication of recirculation flow into tank **28**. As

shown, extension line **59** is also preferably connected to the sprayhead arrangement **52** for spraying recirculated water into tank **28**. The spraying action of the sprayhead **52** creates a preferably continuously moving air to water interface within the tank **28** to thereby inhibit the initiation or growth of biological organisms (including microorganisms) or other contamination. This is in contradistinction to a known bladder surge tank (not shown) having a bladder therein which resiliently expands with inflowing water and returns when a water using device draws water therefrom. Dead air spaces abound therein and provide for the proliferation of contaminants and/or microorganisms. In a speculative embodiment, inlet line **49** from main supply connection line **26** may also be connected to a sprayhead (not shown) such as sprayhead **52** and/or potentially even be connected to the same sprayhead **52**; but more likely each would be separately coupled to distinct sprayheads (not shown).

A pressure valve **60** is preferably disposed in the shunt feedback line **40**, the pressure valve being situated to control the pressure in the outlet flow lines from pump **32**. A pressure sensor/control assembly **61**, including a sensor gauge **63** is preferably disposed on valve **60** to sense the pressure in line **40**, as well as in the output line **31** and the initial portion of line **33** up to filter **70** (if used, see below). A line extension member **62** extends from the valve **60** through an opening **68** into storage tank **28** for flowing water from loop **40** into the interior of tank **28** through valve **60**. The pressure in line **40** controls the activation (restriction) of valve **60**, or more appropriately, the control assembly **61** may be used to set the pressure to be established in line **40** and the pump outlet line **31**, **33**, which pressure is effected by the valve **60**, controlling the pressure out of pump **32**. The pressure gauge **63** may also be used for operator monitoring of the interior pressures in lines **31**, **33** and **40** and a relief valve **64** may also preferably be supplied to relieve excess pressures. An optional, but preferred downspout **65** is shown in dashed lines in Fig. 3 demonstrating the option of feeding water into tank **28** for dispersal at or near the bottom thereof to counteract vortex creation as will be described further below.

In the respective tank outlet and sub-system circulation lines **30** and **33**, a few additional preferred elements are also shown in Fig. 3. Two valves **67** and **69** are shown one each on opposite sides of the pump **32** and may be used to provide for controlling the flows out of the

tank **28** and into the circuit sub-system **25**. A stopcock **45** is also preferably disposed in line **30** to allow for draining water on the inlet side of pump **32**, for maintenance, *inter alia*.

A filtration device **70** is also shown in sub-system supply line **33** and is preferably used here to ensure that the water flowing through the sub-system **25** remains free of contaminants. Two pressure sensors **72, 74**, one on each side of the filter **70**, are used for monitoring and thus also assisting in maintaining proper control of the trans-membrane pressure thereof. Adjacent stopcocks **76**, **78** may be used both during priming and/or for taking test samples as may be desired or necessary (see below). Filtration device **70** may be of several types preferably restricting the transmission of microorganisms and as is preferable herein, it may be an ultra-filtration device, preferably dead-ended as understood in the art, with no cross-flow established through the dead-ended inlet **80A** and outlet **80B**, respectively.

In a general description of use, the sub-system **25** of any of Figs. 1-3 receives water from the main water supply system **10** (Figs. 1 and 2) through inlet line **26** from main system line **14**. This water then fills tank **28** to a preferred level, as described above, with water then also proceeding out through the tank outlet line **30** (if and when valve **67** is opened; Fig. 3). This outlet water is then preferably pumped by pump **32** into and through the sub-system supply line **33**. And, when connected to one or more high-demand machines **20B**, preferably through a respective valve **39** (Fig. 3) at a branch **34**, then during operation of these high-demand machines **20B**, they draw the water they need from line **33** through the respective one or more branch connections **34** and corresponding valve(s) **39**. If sub-system supply line **33** is not dead-ended (as shown with a preferred feedback loop **38** and the optional drain line **36** in Fig. 3), then the unused water flowing through sub-system supply line **33** flows to and through the chosen alternative line path open thereto, drain line **36** or, more preferably in normal operation through the recirculation loop line **38**, for example. Drained water, which would alternatively flow through drain line **36**, would then discharge to a sewer system (or to other optional locations or apparatuses, *e.g.*, it could flow back to the R/O unit **12,** not shown). On the other hand, unused water flowed into and through the preferred recirculation loop **38** will flow to and through the recirculation inlet line **41** into tank **28**, which as above, preferably includes a sprayhead connection **52** for spraying the inlet recirculation water into the tank **28**.

Referring now again to Fig. 3, a more detailed description of the use of sub-system **25** will be presented. Purified water flows into sub-system **25** via inlet line **26** as connected by connection member **42** to the main system supply line **14** (Figs. 1 and 2), preferably via a mating connection member **43** (Fig. 3). A check valve **44** ensures forward one-way flow only into sub-system **25** and the flow control valve **46** allows for a controlled maximum flow rate of the water into the sub-system **25**. When the unit is connected to the main line **14** via connector **42**, water flow may then be allowed to proceed into tank **28**. A float valve **50** can be used to stop inflow of water when a preselected water level has been reached inside tank **28**. Outlet flow from tank **28** proceeds through outlet line **30** to pump **32** which then pumps the outlet water to and through outlet and supply lines **31**, **33**, respectively. When in use, water may and preferably is also pumped through recirculation shunt line **40** back to recirculate into tank **28**. Flow through this line **40** may be operator-controlled as well by a shutoff or three way valve (not shown). However, the preferred use of shunt line **40** provides the user the ability to set the pressure that is supplied to the high demand dialyzer reprocessing equipment through the flow from pump **32** to and through the sub-system line **33**. The pressure regulator assembly **61** can be set to an operating pressure according to preferred reprocessing equipment manufacturer instructions (typically 30 to 40 pounds per square inch (psi)), with the regulated pressure being controlled by the valve **60** and indicated on the pressure gauge **63** attached to the pressure regulating valve assembly **61**. Water will then flow from the pump **32** in a continuous loop through this loop **40** and also then into and through sub-system line **33** under a substantially common pressure set by the pressure regulating assembly **61** (with a controlled transmembrane pressure drop across filter **70**). In either event, control over the operation of pump **32** may be additionally aided by the two flow valves **67**, **69** on the respective upstream and downstream sides of pump **32**, to shut-off flow as may be desired.

Flow through the sub-system supply line **33** preferably receives one more purification step by flow through the dead-ended ultrafiltration device **70**. Pressure sensors **72** and **74** are used to ensure that the pressures therein (particularly the transmembrane pressure thereacross) do not exceed preselected levels. Though not their primary purpose (which is sampling), stopcocks **76**, **78** may also be used in the monitoring and pressure control processes by providing for

relieving excess pressures or pressure differentials as they may occur. As shown, filter **70** is the last mechanical processing element in the flow path prior to the water use machine outlets **34**. This may thus provide further assurance of water purity prior to actual use in the high demand machine or machines **20B**. An unshown alternative placement of filter **70** is in branch line **31** leading out of pump **32** prior to the branch off shunt line **40**. This placement would further ensure purification of water shunted through loop **40** as well.

As mentioned, purified water exiting the filter **70** shown in Fig. 3, then travels along supply line **33** and branches therefrom through a respective branch connection **34** when a demand for water is presented by a high demand device **20B** connected thereto, the respective valve **39** also being opened to permit flow therethrough. Used water then flows out of that device **20B** through the drain line **21** preferably to the sewer system (not shown).

Unused water at this point then travels preferably, as shown in Fig. 3, through a recirculation loop **38** back to storage tank **28** via the inlet line **41** and sprayhead **52**. The spray action creates a preferably constantly moving air to water interface within tank **28**, especially along the interior surface thereof. Such movement assists in reducing the likelihood of biological growth inside the tank **28**. Preferably also, some unused water is simultaneously recirculated through shunt line **40**. Pressure valve **60** is used primarily to control the pressure of the fluid in outlet flow line **31** and the supply line **33**, at least in that portion of supply line **33** which is directly upstream of filter **70**. Then, so long as the pressure drop across the membrane is sufficiently managed (through monitoring thereof using gauges **72**, **74**), then the pressure of the water flow through all of supply line **33** can be controlled to present the proper operating pressures to the high demand device(s) **20B** connected thereto. Note, during operation, recirculation is preferably constant through both feed back lines **38** and **40** and pump **32** continually running regardless whether high demand device(s) **20B** are drawing water therefrom. Moreover, flow into tank **28** through line **26** from main line **14** will preferably be more intermittent wherein it is substantially constant until a minimum level of water is achieved in tank **28** (even with water preferably continually being pumped therefrom into the rest of the circuit sub-system **25**), but, then is turned off by the float valve **50** until a sufficient draw by one or more devices **20B** sufficiently lowers the operating volume in tank **28**. Such substantially

constant recirculation flow may, as preferred, enter tank **28** both near the top of tank **28** through a spray head **52** (from loop **38**, e.g.) and simultaneously dispersed in or near the bottom of tank **28** (from loop **40**, e.g.) for the purposes described above.

The intended purpose for the entire supply sub-system **25** is as a "buffer" between a main supply line **14** fed by a treatment (e.g., reverse osmosis (R/O) or de-ionization (DI)) machine **12** providing water at a constant rate, and one or more dialyzer reprocessing machines **20B** and/or other machine processes consuming water at a variable and intermittently high rate. The reuse supply sub-system **25** receives water from the R/O unit **12** at a constant rate into a relatively small, preferably about a 30-gallon reservoir **28** and, by means of a pump **32** (preferably a centrifugal type) and a pressure control mechanism (see pressure regulating valve/assembly **60/61**), provides this water to dialyzer reprocessing machines **20B** at a constant pressure and variable rate. Even so, the output capacity of the R/O machine **12** would still preferably exceed the combined consumption rates of all dialysis applications (machines **20A**) and the average consumption rate of all dialyzer reprocessing applications (machines **20B**) operating simultaneously.

The reuse supply sub-system **25** is preferably to be connected to a purified water distribution main system (see system **10**; Fig. 1) that supplies water meeting current Association for the Advancement of Medical Instrumentation (AAMI) requirements for dialyzer reprocessing (i.e., "AAMI Standard") and other AAMI requirements as applicable (e.g., hemodialysis machines and hemodialysis concentrate) as applicable.

In preferred operation particularly in a dialysis setting, the AAMI standard water enters the sub-system **25** through a two-piece stainless steel coupling known as a "quick disconnect" including the water inlet connection **42** and the corresponding outlet connection device **43**. The main water distribution (R/O) side of the quick disconnect preferably has a "female" connector **43** with an internal shut-off valve (not shown), while the reuse supply sub-system side of the quick disconnect has a "male" connector **42** with or without an internal shut-off valve. After passing through the quick disconnect, water next flows through a check valve **44**. The check

valve **44** prevents inadvertent backflow of water or disinfectant chemicals from the reuse supply sub-system **25** into the purified water distribution system **10**.

Water next flows through flexible tubing line **26** and passes through a flow control valve **46**. The flow control valve **46** regulates water flow into the reuse supply sub-system **25** at a rate that does not exceed R/O unit **12** output capacity. Typically, the flow control valve **46** regulates flow to approximately one and one-half (1.5) gallons per minute (gpm), although other sizes may be provided according to individual requirements and capacities.

Inlet water next passes through a float valve **50** before entering the tank **28**. The float valve **50** controls the maximum level or height to which the tank **28** can be filled. Once the tank **28** is full to the preferred, predetermined level, the float arm assembly **51** will shut off the incoming water supply to the tank **28**.

The tank **28** is preferably constructed of polyethylene, has a respective concave (dished) top and bottom, and a preferred maximum capacity of about 30 gallons. The tank stand (not shown) is preferably non-metallic and includes a pump mounting surface directly below the tank **28**. The top of the tank **28** has a larger (e.g., six inch) threaded access port **55** that is hermetically sealed closed preferably by a correspondingly sized (e.g., six-inch) threaded PVC cap preferably sealed with Teflon tape on the threads. This opening is provided as a service and assembly access port. It should not be opened under normal circumstances, and should remain closed during operation to ensure a leakproof and airtight seal. There is also a preferable two-inch port **56** fitted with a levered male camlock and dustcap connector (not shown in detail). The levers on the dustcap would allow it to be easily opened and closed. This port **56** provides easy access for adding chemical disinfectants to the sub-system **25**. Properly attached, the dustcap makes an airtight seal. Other elements adjacent and/or connections to the top of the tank **28** are preferably disposed at the spray head inlet line **41**, the Pressure Relief Valve (PRV) **60** inlet line **62** and the vent connection for the 0.2 micron air vent filter **52**. At the bottom of the tank **28** is a preferable one-inch piping line connection from which water flows from the tank **28** into water line **30** and the inlet to the pump **32**.

At the bottom of the tank **28** is a valve **67** that when opened allows water to flow to the pump **32**. This valve **67** is primarily an aid for servicing purposes and is not preferably used during routine operations. The pump **32** is preferably yet only typically capable of pumping up to 10 gallons per minute at 45 pounds per square inch (psi). Other pumps, larger or smaller, may be used to provide for various flow and/or pressure requirements; for example, 15 gallons may also be typical in a cleaning/sterilizing environment for medical or other high quality uses. The output line **31** of the pump **32** is then preferably connected to a tee fitting to split flows through sub-system supply line **33** and recirculation shunt loop **40**.

Thus, one side of the tee junction directs flow through shunt line **40** to a Pressure Relief Valve (PRV) **60** and pressure regulating assembly/gauge **61/63**. In the preferred embodiment, connected to extension line **62** inside the tank **28**, is a downspout **65** (shown in dashed lines), which directs the flow to the bottom of the tank **28** and disperses it to prevent formation of a vortex (swirling). This may also help to avoid the possibility of air getting into the pump **32** via such a vortex. The PRV assembly **61** allows the user to set the pressure that is supplied to the dialyzer reprocessing equipment **20B** via line **33**. The regulator should be set according to reprocessing equipment manufacturer instructions, typically 30 to 40 psi (taking into account any pressure drop between the pump **32** and the outlet(s) **34**, e.g. across filter **70**), with the regulated pressure being indicated on the pressure gauge **63** attached to the PRV assembly **61**. Water will flow in a continuous loop through the flow path defined by the loop **40**. Flow path **40** also preferably includes a stainless steel female quick disconnect connection member **66**, also referred to herein as the recirculation connector **66**, for use during rinse and disinfection procedures (to be described below).

The other side of the tee junction out of pump **32** and line **31** directs flow through a sub-system supply line **33** which preferably includes a FiberFlo® hollow fiber cartridge filter **70** (available from the Minntech Corp., Minneapolis Minnesota) and then to outlets for one or more dialyzer reprocessing machines **20B**, a drain valve/line **37/36** (dashed lines), a recirculation loop **38**, and then back into the tank **28** via a spray head assembly **52**. The first component downstream of the tee branch junction is a valve **69** that can isolate flow from the storage tank **28** and PRV recirculation shunt path **40** from the dialyzer reprocessing equipment outlets **34**. This is

followed by a pre-filter pressure gauge **72**, used to measure pressure at the inlet of the filter **70**. A sample port **76** has been placed at or near the filter inlet to permit pre-filter sample collection. The preferred filter **70** is the FiberFlo® filter introduced above, 20 inches long (nominal) and is constructed of polysulphone hollow fibers rated by the manufacturer to remove both bacteria and bacterial endotoxin. The cartridge-style filter **70** can be removed from the housing and replaced during routine maintenance or when microbial or delta pressure monitoring (transmembrane pressure taken from gauges **72** and **74**) indicates a need for filter replacement. The filter housing includes connections and/or sample ports **80A** and **80B** at the top and bottom to either vent or flush the housing (and could alternatively be used in an ultrafiltration manner to provide a flow of a clean fluid on the on the opposing side of the membrane therein, though not preferable here). A sample port **78** has been placed at or near the filter outlet to permit post-filter sample collection and follows (or may be followed by) a post-filter pressure gauge **74**. The pre- and post-filter pressure gauges permit filter pressure drop monitoring/measurements (an indicator of either fiber breakage or plugging) as well as of the pressure being supplied to the reprocessing outlets **34**. Although the order of these outlets may vary, the first few outlets **34** following the filter assembly **70** may preferably be valved outlets for pre-rinse, clean sink (clean water) connections. Then, the next one or more outlets **34** are preferably valved outlets for dialyzer reprocessing equipment **20B**. Lastly, preferably the drain valve **37**, closed during normal operation, would allow for the operator to drain the tank **28**. Then, water returns to the tank **28** via the recirculation loop **38** and the spray head assembly **52**.

Various ancillary preferred operating procedures for the preferred dialysis reuse machine sub-system **25** in connection with a main circuit **16** will now be described.

The following is a system start-up procedure which presumes power to the pump **32** is turned off, the tank **28** is empty, and has been disinfected and rinsed.

First, the drain valve **37** should be verified as closed. Then, the inlet water line **26** is connected to the water supply quick connection via connect devices **42/43**. The tank **28** will begin to fill. Then, after the tank **28** is approximately one-third (1/3) full, the pump switch may be turned to the on position, allowing the pump **32** to run and circulate water. Pressure readings

across the filter **70** and at the pressure regulator gauge **63** should be verified that they are within specifications. The tank will continue to fill until the level is maintained by the inlet float valve **50**.

Then, at the end of the desired period of operation, a system shutdown procedure includes draining the tank **28** as now described after each desired period (e.g., a day) of use. In particular, draining the tank **28** includes disconnecting the inlet water line from the main line **14** by disconnecting member **42** from member **43** and then connecting the inlet water line **26** to the recirculation connector **66** for connecting the sub-system **25** the position shown in Fig. **4**. Then, the pump **32** is turned on and the drain valves **67** and **37** are opened; and, the tank level is observed. Then, after the water drains out of the tank **28**, the pump **32** is turned off. Note, the pump **32** should not be run after the tank **32** has been drained, as air could then enter the pump **32**, and then damage to the pump **32** may result.

The reuse supply sub-system **25** should preferably be left with the water supply quick connection **42** plugged into the recirculation connector **66** at the end of each period's (e.g., day's) use. Overflow of the tank **28** or damage to the reuse supply sub-system **25** may result if in instances where an R/O system has the capacity for heat disinfection and if the water supply quick connection **42** is left connected to the R/O main line distribution loop **16**.

Another set of ancillary procedures include disinfection and cleaning. In exterior cleaning, the unit **25** should first be unplugged from the power (preferably 120V) connection (not shown). Then, non-electrical exterior surfaces may then be cleaned preferably with a 1% Renalin® or other peracetic acid cleansing solution. A spray disinfectant solution should not be sprayed on the power switch, motor or like electrical components. These may be wiped with a damp cloth containing water only.

In periodic, preferably weekly, disinfection of the tank **28** and fluid pathways (pipe or tubing lines); first the tank **28** should be drained or filled, as needed, so that the tank level is preferably approximately one-third (1/3) full. (If draining the tank **28**, it will be preferred and/or necessary to disconnect the water inlet line **26** from the main water supply **14** (to halt further

inflow from main line **14**), and then reconnect it to the recirculation connector **66** in shunt loop **40**; see Fig. 4.) Then, the power to the pump **32** should be turned off, and, the inlet water line **26** should be verified as connected to the recirculation connector **66** as shown in Fig. 4 and the drain valve **37** as closed. Then, the cap to the disinfection port **56** at the top of the tank **28** is removed, preferably by lifting the locking arms (if such a mechanism is used) on the sides of the cap. Preferably, approximately one-half (½) a quart of Renalin® or like peracetic acid disinfectant is poured into the tank **28** through the access port **56**. It is cautioned that appropriate Personal Protection Equipment (PPE) should be used to prevent peracetic acid exposure to skin or eyes. Then, the disinfection port cap is replaced over the port **56** and locked in place by pressing the locking arms (if used) down all the way. Again, other locking means may be used to lock the disinfectant access port cap onto/over the port **56**, preferably in an airtight sealed relationship.

Next, the pump **32** will be turned on, and the sub-system **25** should be allowed to recirculate, preferably for about a minimum of five (5) minutes. A small container (not shown) may then be placed under the pre-rinse and/or clean water connections (i.e., the preferable first one or more connections **34** after the outlet from filter **70**; also known as spigots **34A**, or valved spigots **34A**; see Fig. 4), and then the valved spigots **34A** slowly opened to allow the disinfectant to flow out of the each such spigot **34A**. A hose (not shown) attached to each such spigot **34A** may also be used. These last few spigot opening steps should then be repeated for any other valved connections on line **33**, including any clean water spigot (not separately shown), or any such connections **34** (see Fig. 3, e.g.), including the re-use connections **34**, particularly those not connected to a re-use or other high demand machine. However, the opening of the valved connections **34** which are connected to a re-use machine (such as connection **34B** connected to machine **20B** in Fig. 4) may also be desirably opened to run disinfectant solution therethrough at this point in the procedure as well, even though the disinfectant solution would then be destined to be flowed into the high demand machine **20B** (disinfection thereof would follow the manufacturers' suggestions/requirements, but could be run simultaneously or close in time with disinfection of the rest of the sub-system **25**).

To then conclude the circulation of the disinfection solution through sub-system **25**, first a test of the solution potency or concentration at the sample port **78** downstream of the filter **70**

and the pre-rinse and clean water spigots **34A** is run using a test strip recommended by the peracetic acid manufacturer. The results of this test are recommended to be positive (≥ 500 ppm of peracetic acid). Then, the pump **32** can be turned off, and the sub-system **25** may now be allowed to dwell for a down/inoperative period, such as overnight or for over-the-weekend storage. The minimum dwell time for storing the sub-system **25** filled with peracetic acid solution is preferably about two (2) hours.

The following tank and fluid pathways rinsing steps may then be followed after disinfection (and a preferable minimum dwell time, e.g., 2 hours; see above), assuming preferably that the above disinfection solution circulation steps (or the like) had previously been taken.

The operator first verifies that the inlet water line **26** is connected to the recirculation connector **66**, as shown in Fig. 4. Then, the tank **28** is drained using the following sub-steps. The pump **32** is turned on, the drain valve **37** is opened, and then, the tank level is monitored, until the water and disinfectant solution is drained out of the tank **28**. Then, the pump **32** is turned off, again cautioned to not run the pump **32** after the tank **28** has drained, as damage to the pump **32** may result.

Next, the inlet water line **26** is connected to the main water supply line **14** via the quick connection member **42** at a branch **18** (see completed schematic connections in Figs. 1 and 2, e.g.). Then, the tank **28** will begin to fill with purified water from the purified water main system **10** through line **26**. The sub-system drain line **37** is also closed. The tank **28** is allowed to fill until it is approximately one-third (1/3) full (the tank drain valve **67** may also be closed temporarily during initial filling process, then opened). Then, the pump **32** is turned on.

The pre-rinse and clean water spigots **34A** (see Fig. 4) are next opened briefly to allow some fresh water to flush through these spigots **34A**. A container or a hose (neither shown) may be used (or needed) to catch the water leaving each such spigot **34A** if it is not so situated as to drain directly into a sink or like receptacle (not shown). The drain valve **37** is then opened. And, the tank level is then monitored. After the water drains out of the tank **28**, the pump **32** is turned

off. Again, the pump **32** should not be operated after the tank **28** has drained, as damage to the pump **32** may result. These last several steps (from filling the tank **28** and rinsing through the sub-system **25**) are preferably repeated until a negative test (≤ 3 ppm of the disinfectant cleaning solution, such as Renalin® or equivalent peracetic acid) for the presence of the disinfectant solution (Renalin®/peracetic acid) is obtained at the post-filter **70** sample port **78** and/or the pre-rinse and clean water spigots **34A**, or the like.

The following disinfection steps are particularly additionally applicable when using a portable R/O unit (not separately shown) as the main supply system purification unit **12** (see Fig. 1). The portable R/O unit **12** should first be verified as turned off. The reuse supply tank **28** should then be drained as indicated in the steps set forth above (turning on the pump **32**, opening the drain valve **37** and monitoring the tank level). Then, a disinfection procedure of the portable R/O unit **12** may be performed preferably per the manufacturers' guidelines. Peracetic acid based disinfectants should preferably be used. Then, upon completion of the portable R/O disinfection process, the reuse supply tank **28** is drained of any water that may have entered the tank **28** as a result of the portable R/O disinfection process. Then, the reuse supply tank **28** and the rest of sub-system **25** are disinfected and rinsed as described above.

Various preferred maintenance procedures will now be described.

The steps for replacing the preferred filter **70** will now be described. When, as measured by the respective pressure gauges on opposing sides of the filter **70**, the differential (transmembrane) pressure across the preferable membrane (hollow fiber, plate or otherwise) filter **70** exceeds the manufacturers' recommendation, or a recommended time period has been reached, or when microbial monitoring indicates the desirability thereof, the filter **70** may be changed as follows. (Note, the preferred filter **70** is a FiberFlo® Hollow Fiber Cartridge filter, manufactured by the Minntech Corporation, Minneapolis, Minnesota. FiberFlo® is a registered trademark of the Minntech Corp. Hollow fiber cartridge filters of this type have also been known as ultrafiltration devices or ultrafilters, and such and other alternative filters are also intended to be useful herein as well.)

First, the sub-system supply tank **28** should be drained and/or at least the valve **67** may be closed. The filter **70** housing can then be drained using the connection spigot **80B** at the bottom of the housing. The filter **70** housing can then be opened and the filter membrane can be removed (in the preferred FiberFlo® filter, a simply removable and replaceable cartridge simplifies this removal). A filter wrench (not shown) may make it easier to open the housing. A new filter membrane (and/or cartridge) may then be installed and the housing closed and sealed shut. The inlet water line **26** may then be connected to the main water supply line **14** via the quick connector device **42** at a branch **18** as described above. The tank **28** is then filled, preferably to about one-third (1/3) full, at which point the pump **32** is preferably turned on. The filter **70** is then preferably flushed according to manufacturer guidelines. A disinfection procedure may then preferably be performed of the sub-system supply tank **28**.

The replacement of the preferred vent filter **54** is manufacturer recommended at a replacement interval of six (6) months when used regularly in the application described herein above. The preferred vent filter **54** is a five (5) inch 0.2 micron vent filter is manufactured by Waterlink Technologies of West Palm Beach FL. The replacement includes the draining of the re-use supply tank **28** first, and then includes unscrewing the filter housing (not separately shown) and removing the filter. Then the new filter is installed and the filter housing is replaced and tightened.

The pressure regulator **61** adjustment process usually involves filling the tank **28** until it is at least about one-third (1/3) full and then turning the pump **32** on. The regulator **61** may then be adjusted until the pressure reading on the PRV gauge **63** reads the preferably pressure for supply to the supply line **33** and the high-demand machines **20B**; here, preferably about thirty to forty (30 - 40) psi.

A preferred long term storage procedure will now be set forth. The tank **28** should first be disinfected per the above instructions, leaving a 1% peracetic acid disinfectant solution in the tank **28** and in the fluid pathways **26**, **30**, **31**, **33**, **38**, and **40**, *inter alia*. The pump **32** may then be unplugged from the power (120V) connection (not shown). The 1% peracetic acid disinfectant solution may preferably be replaced every two weeks per above instructions. For

storage intervals greater than one (1) month, the system should be fully drained of liquid and the FiberFlo® filter **70** removed. Upon removal from this storage, a new FiberFlo® filter **70** should be installed and then the system should be disinfected again per the above instructions.

Various warnings and/or cautions should now be addressed. For example; the reuse supply system may preferably be disinfected with Renalin®, Minncare® (Renalin® Minncare® and FiberFlo® are registered trademarks of Minntech Corporation, Minneapolis, MN.) or other peracetic acid solutions of like concentration that have been diluted in a ratio of 1:100 with purified water meeting the current requirements of the Association for the Advancement of Medical Instrumentation (AAMI) for dialyzer reprocessing. Always follow manufacturer's recommendations for the handling, storage and use of peracetic acid solutions, including those given for potency and residual testing.

And, as a point of caution, it should be noted again that the pump **32** should not be operated with an empty tank **28**. Operation of the pump **32** with an empty tank **28** will damage the pump unit.

Also, various alternative embodiments may be available. In one or more alternative embodiments (not shown), the two recirculation loops **38**, **40** may be connected to each other prior to entrance into the tank **28**. Thus, they could then both be connected to a sprayhead **52** or to a mere inlet extension **62** or even to a downspout **65**. Nevertheless, such a connection is not preferred because the separate functionalities of both the sprayhead **52** (agitating the water/air surface in tank **28**) and the downspout **65** (counteracting any vortex action at the exit from tank **28**) are preferably retained in the preferred embodiment. Furthermore, the outlet pressure of pump **32** is controlled by the pressure regulating valve/assembly **60/61**. In another alternative embodiment, the recirculation loop(s) **38**, **40** could be connected to inlet line **26**, and then the recirculation inlet to tank **28** could be defined as identically indistinct from the primary inlet **48**. Thus, there could be only one inlet line, with the recirculation line(s) connected to the main supply connection line **26**. However again, the separate functionalities of the separate inlets is preferred. Note, as preferred, the inlet flow from the main line **14** through line **26** is controlled to a maximum draw rate from line **14** by the control valve **46**, and this inlet flow will preferably be

stopped by the float valve **50** when a sufficient maximum volume is detected in the tank **28**. However, it is preferred that during operation, a continuous flow of water cycles through the feedback loops **38, 40** to provide a continuous spray of water spraying through sprayhead **52** and a continuous vortex counteraction from downspout **65** (so air does not reach pump **32**).

Moreover, as a further aid to prevention of microbiological growth, an alternative embodiment ultrafiltration device (not shown), perhaps like ultrafilter **70**, may be disposed in and adjacent either of the tank inlets for recirculation lines **38, 40** just prior to re-entry of recirculating water into tank **28**. Disposition in either or both of these inlet lines provides for ensuring the purification of the water recirculated through either recirculation loop **38** or shunt **40**. Otherwise, similar ultrafilters could separately be placed in other locations in either or both of these recirculation loops **38** and/or **40**. Another alternative placement of an ultrafilter **70** is in pump outlet line **31** to ensure contamination free flow after pump **32** regardless whether the flow is shunted through line **40** or run through supply line **33**, drained or looped back through line **38**. However, outlet pump pressure control using a pressure regulating valve/assembly **60/61** would not be a direct control if situated downstream of such a filter **70**, and may not be as effectual as in the preferred embodiment. Furthermore, depending primarily upon capacity, parallel dispositions of ultrafiltration devices such as device **70** may be established to ensure a sufficient quantity of flow through the filtration portion of the sub-system circuit.

A couple of further possible alternatives could involve pump controls (not shown). For example, high and/or low water sensors disposed inside the tank **28** could signal respective high and or low water levels which could then be converted into control signals to either turn the pump **32** on or off. For example, a low water sensor (not shown) could be disposed to sense when too little volume remains inside tank **28**, and therefore sends a signal which is ultimately used to turn the pump **32** off (effectively, a low-water cut-off device to stop the pump). A pump protective higher sensor in tank **28** could then be used to indicate that a sufficient minimum quantity of water is disposed inside tank **28** so that it would be safe (low or no opportunity for air entry therein) then to turn on pump **32**. The signal could itself be converted to control pump **32**. A similar high water level sensor could similarly be used in lieu of (or as a fail safe in addition to) the float valve **50** to halt flow into tank **28**. As a more particular (yet, non-limiting) example

of this, a sensor and valve configuration could be used to actually halt the flow of water into the tank at a high level point. A normally closed valve (e.g., a valve which is closed when no power is provided thereto) may be used in conjunction with a high level sensor such that when no water is in contact with the sensor, power is allowed to be continually provided to the valve so that the valve is in an open state to provide continual inflow of water into the tank. Then, when the tank fills sufficiently such that water does reach and contact the sensor, the sensor provides a signal (preferably through a relay or like device) to halt power to the valve, which then closes and thereby stops flow of water therethrough and into the tank. Such a valve could also be connected to the power supply to entire system, whereby halting such power to the overall system, would then also cut off power to the valve so that the valve then closes. This could then act as a failsafe in case overall power is unexpectedly lost, and/or could act as a regular (e.g., nightly) flow stoppage mechanism, for example, when operation is to be ended at the end of each day, then turning off the overall power will then shut the valve off and stop the flow of water into the tank. In this way, then, water flow in loop **16** need not be stopped at the end of each day, nor would system **25** need to be disconnected therefrom, even if loop **16** is disinfected or otherwise has other flows therethrough after normal operation.

The pump **32** could also have characteristics allowing for increasing pump output if it sensed that the re-use or like high demand machines **20B** were demanding such quantities of water that they might overwhelm the present pump output. The pump may then include the necessary internal elements for sensing the need for a greater output, and/or there could be disposed certain pressure and/or flow meters or the like (not shown) in the respective flow lines, e.g., sub-system supply line **33**, to provide feedback to the pump **32** to start, stop or change output, positively or negatively as needed.

The present invention may take many forms in distribution or the like. For example, the present invention may involve distribution of a sub-system kit which may be incorporated later in/on an otherwise substantially independent main water supply system. Advantages in expense and/or automation may be realized here. Alternatively, the sub-system may be manufactured and distributed as part of an entire water supply system which includes the main supply line with or without water purification devices.

As noted, systems of the present invention may be highly beneficial in numerous water supply systems including those requiring purified water such as in medical applications like dialysis, or may also be useful in pharmaceutical preparation or electronics manufacturing or other water supply processes. In each of these or other uses, the present invention handles the delivery of water in a main loop for relatively low, often substantially constant demand devices together with the delivery through a sub-system of relatively higher demand water usually at more intermittent intervals. It should also be noted that the present invention may be used with or without purification water supply systems.

Also, though it may be noted that the present invention handles pressure fluctuations which may be incurred by having both low and high demand water using devices on a water supply line; the present invention may also be directed to handling other water handling issues as well. For example in the medical dialysis field, heat issues may be handled by the present invention. Heat sterilization of a main water supply line or loop is common in the dialysis water supply field; however, heat sterilization processes are not compatible with state-of-the-art re-use machines. The present invention effectively isolates the re-uses machinery from the main loop so that the re-use machines are not exposed to the high temperature water (or other fluid) flowing through the main loop. Similarly, it is common situation that re-use machines are preferably disinfected using a chemical solution or disinfectant, and the present invention provides an isolated ability to provide such a chemical to the re-use and/or other dialyzer pre-use cleaning or like equipment connected to the sub-system. The chemical solution or disinfectant may be placed in the smaller storage tank of the sub-system and circulated throughout the sub-system as shown for example in Fig. 4 in an isolated manner separately from the disinfection/sterilization process of the main system (which as described here, could be heat-based).

Accordingly, a new and unique invention has been shown and described herein which achieves its purposes in an unexpected fashion. Numerous alternative embodiments readily foreseeable by the skilled artisan, which were not explicitly described herein are considered within the scope of the invention which is limited solely by the claims appended hereto.